

Impedance Based Detection of Corrosion

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Corrosion detection, replacement, and repair costs the United States 4.2% of the Gross National Product each year. Although corrosion is a costly problem in many structures, it tends to present greater problems for aircraft because of extended service lives. U.S. Air Force aircraft like the C/KC-135s, B-52Hs, C-5As, and C-130s were designed for service lives of 20-30 years; however, due to budgetary concerns some of those aircraft will reach service lives of 60 to 80 years. Thus, for extended service intervals, corrosion induced fatigue may well be the service limiting factor for aircraft. Therefore, identifying and assessing the presence and growth of corrosion and predicting its effect on fatigue induced crack growth is of utmost importance

Corrosion begins as moisture penetrates the protective barrier of a surface, starting an electrochemical process which leads to surface pitting. Structural integrity is reduced as the pits enlarge to form nucleation sites for surface cracks, which propagate into through-the-thickness cracks. Precise structural health monitoring of pre-crack surface corrosion is paramount to understanding and predicting the effect corrosion has on the fatigue life and integrity of a structure. Initially, corrosion induced damage and impedance shifts are small relative to the induced damage and impedance shifts of most traditional damage detection experiments. Therefore, resolving the corrosion induced damage from the random variation, noise, and error within the experiment requires additional corrosion specific experimental procedures to ensure detection. In this study, the procedural variations required to detect corrosion with the impedance method are presented. The impedance method was experimentally tested to detect and quantify the onset and growth of pre-crack surface corrosion of structures in one and two dimensions. Experimental results indicate the method is an effective detection and tracking tool for corrosion induced structural damage. Additionally, the impedance method was evaluated as a damage location tool for 1-D and 2-D structures.

A simple beam was tested for light chemical corrosion damage (pits less than 0.001 inches) at four different locations. A picture of the test setup may be seen in Figure 1. Each instance of corrosion damage accounts for less than 1.4% of the surface area, and is located 2.75 cm, 3.60 cm, 18.0 cm, and 31 cm from the sensor.



Figure 1: The 46 x 2.54 x 0.063 cm aluminum test structure shown with four levels of damage.

The experimental results of the corrosion detection tests demonstrate the ability of the impedance method to detect light corrosion damage and indicate corrosion damage accumulation. The first five bars from left to right in Table 2 are baselines measurement meaning there is no relative damage for each measurement, thus the damage metric is nearly zero. The next four bars indicate one level of relative damage, and each is easily distinguished from the baseline cases. The other bars depict two, three, and four levels of relative damage, and each shows the ability of the method to detect the accumulation of corrosion damage.

Table 1: Damage detection and accumulation results for corrosion testing.

